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DISCUSSION

Dr Christopher G. Carsten, III (*Greenville, SC*). In the current study, Dr Kirkwood and colleagues have updated their database on the radiation exposure of patients undergoing complex endovascular procedures and examined the frequency and severity of skin injuries associated with exposure to greater than 5 Gy of radiation using reference air kerma (RAK) to determine the radiation dose level. Peak skin doses (PSDs) were calculated with custom software from fluoroscopic machine logs and correlated to Gafchromic film exposures. Skin injuries were detected by retrospective chart review and phone interviews of patients.

Transient skin erythema has been previously reported with doses starting at 2 Gy. In this study, the average RAK was 7.7 Gy, and the mean calculated PSD was 6.8 Gy. Notably, 15% of patients in this series received greater than 10 Gy of PSDs; however, no patient in this series was identified as having even grade 1 skin injury, leading the authors to conclude that perhaps the deterministic effects of radiation exposure are somehow lower in our patients than in previously reported series.

I have several questions for the authors.

In reviewing your manuscript this year and comparing it with the manuscript presented at this meeting last year, I noted that at your institution an educational event was undertaken to educate surgeons on radiation safety after it was noted that there were a number of procedures with patient exposures of more than 6 Gy. No mention is made in the current manuscript of the chronologic distribution of patient exposures. Did the higher exposures occur earlier in the series when there was less radiation awareness and thus less attention at follow-up examinations to possible injuries?

In the same vein of thought, this study relies on retrospective chart review to detect the presence of a red rash or ulcer found on a vascular patient's back. In the manuscript, you qualify that it was assumed that a full physical examination was conducted at each of the patient's follow-up visits. I do not know about at your institution, but many vascular notes that I read tend to focus on the front of patients with scant mention of their skin or back. Could you comment on the number of charts that contained specific documentation of either a skin or back examination?

Finally, given vascular surgery's lackluster history of radiation safety awareness and compliance, is the apparent message that our procedures are somehow less likely to cause skin injury to our patients compared with prior reports by other specialties the appropriate message that we wish to convey?

I applaud your efforts to continue to draw the attention of our specialty to an area of our practice that has been ignored for too long.

Dr Melissa L. Kirkwood. Thank you, Dr Carsten, those are wonderful questions that address important points. To address the first question, yes, we did present a manuscript last year on how surgeon education in the appropriate use of operating factors can lower PSD. If you look at the case distribution of the cases that reached 5 Gy RAK before and after the surgeon educational event, you see that the outlier cases, visceral interventions, standard endovascular aneurysm repairs, and thoracic endovascular aortic repairs, were only in the pre-education group. After surgeon education, only fenestrated endovascular abdominal aneurysm repair (FEVARs) continuously required high radiation doses. This suggests that we are using appropriate technique to limit dose; however, case complexity is a main contributor to increased radiation exposure.

To address the second question, there are several limitations to this study, and you point out the biggest one. It was a

retrospective review, so it was assumed that a physical examination of the back was performed in the clinic at each visit, and that may not have always been done. That is why we relied heavily on the telephone interviews, in which we directly asked patients about any history of skin-related complaints after their complex endovascular procedure. I also looked at all medical notes to see whether each patient had any dermatology visits or primary care appointments for skin complaints. Two patients were seen by a dermatologist, one had a culture-positive herpes outbreak, and another suffered a diffuse desquamating skin reaction secondary to an antibiotic. The possibility of inadequate skin examinations during follow-up is a weakness of the study because some minor grade 1 or grade 2 injuries could have been missed. That is why during the last 6 months we have changed our routine to ensure that all FEVAR patients are questioned about skin erythema, ulceration, desquamation, and necrosis and that each patient has a full skin examination.

In terms of the third question, no, I do not believe that our patient population is any different from, for example, the patients who developed radiation-induced skin injury in the coronary literature. However, as demonstrated by the PSD maps from FEVARs, there is a great amount of gantry angulation in these cases that tends to spread skin dose much more than perhaps a coronary intervention, in which the radiation is limited to a smaller area. This dose spreading decreases the PSD to any one area and thus decreases the potential for injury. This study highlights that conventionally considered risk factors for skin injury are not clear and we do not know who is most susceptible. Therefore, more prospective data are needed to be able to properly identify patients at risk for radiation-induced skin injury.